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MASS REARING THE FALL ARMYWORM IN THE LABORATORY

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MASS REARING THE FALL ARMYWORM IN THE LABORATORY[1/]

By R. L. Burton[2/]

Fall armyworms [Spodoptera frugiperda (J. E. Smith)] have been reared in the laboratory on a small scale with a variety of techniques. Waters (11)[3/] and Roberts (9) each used similar methods of rearing this insect on foliage from corn, beans, and millet. Revelo and Raun (8) placed first-instar larvae on plant tissue; then when they reached the second instar, the larvae were transferred to vials containing the diet developed for the European corn borer (2). Bailey[4/] reared the insect in cups, vials, and sectioned trays with a modification of a diet discussed under the section, "Larval Diet." However, the demands for the fall armyworm at the Southern Grain Insects Research Laboratory in Tifton, Ga., became too great to be accommodated by these processes, primarily because of the large amount of slow handling techniques required and the high cost of hand labor.

CULTURE

The culture of fall armyworms used at the Southern Grain Insects Research Laboratory was originally collected from

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1/ Entomology Research Division, Agricultural Research Service, U.S. Department of Agriculture, in cooperation with the University of Georgia, College of Agriculture, Coastal Plain Experiment Station.

2/ Entomologist, Tifton, Ga.

3/ Underscored numbers in parentheses refer to Literature Cited, p. 11-12.

4/ Bailey, D. L. Development of techniques for mass production of lepidopterous larvae for use in connection with sorghum insect resistance studies. 77 pp. Stillwater, Okla. 1964. [Unpublished doctor's thesis. Okla. State Univ.]

bermudagrass in 1959 and 1960 and reared continuously on various forages.[5/] A portion of this culture was acquired by the laboratory in 1962 and reared on sections of corn ears until 1965.[6/] During these 3 years, the culture was selected for large adults and consistency in pupation. Then, in 1965, I converted the culture to a meridic diet (described under the section, "Larval Diet") on which the larvae have been reared continuously to the present (1966).

REARING PROCEDURES

Emergence and Oviposition Cages

Cages are 1 cubic foot in size (7, 12) and have two opposite removable sides (fig. 1). They are constructed of 3/4- by 3/4-inch wooden strips, transparent polyethylene sheeting, and 14- by 18-mesh aluminum screen wire as follows: Four of the six sides are built separately from the wooden strips, and the plastic sheeting is stapled to each side. These sides are then bolted together with the plastic toward the inside. Also two squares (10-1/2 by 10-1/2 inches) that will fit snugly into the two open ends are built by covering the wooden strips with screen wire and putting them in place but not securing them. White paper dinner napkins (about 12 by 14 inches) are placed against the screen wire and inserted into the cage where they serve as oviposition sites. The napkins are held in place only by the close fitting removable sections and can easily be replaced.

About 40 pupae in a small paper cup are put inside each cage. Each cage is then placed so that one removable side (with a napkin) rests against a Sylvania panelescent "nite lite". These lights plug directly into electrical outlets installed in a series along each shelf in a controlled temperature room (24° C. and relative humidity of 78 percent) and are operated continuously. Fluorescent bulbs operated on timers provide 14 hours of "daylight" in the room.

When the moths begin to emerge, they are fed from a folded square of cheesecloth or absorbent cotton that has been

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5/ E. W. Beck, personal communication, Entomology Research Division, Agr. Res. Serv., USDA, Tifton, Ga.

6/ J. R. Young, personal communication, Entomology Research Division, Agr. Res. Serv., USDA, Tifton, Ga.

Figure 1.--Emergence and oviposition cage.

saturated with beer and placed in a shallow container. This food container is replaced daily. The oviposition napkins are replaced in a dark room where low-intensity lights have been installed in the wall (fig. 1). When one end of the cage is placed against this light, the opposite end may be opened without many moths escaping, because they are attracted toward the light. Also an exhaust fan in the dark room removes most of the insect scales from the air; however, those who work in the room usually wear surgical face masks. After each use, the cages are scrubbed in soapy water, dipped in germicidal solution, and ovendried at a low temperature.

Egg Incubation

The napkins with eggs are cut into 4-inch-wide strips and placed in widemouthed pint jars. The jars are capped with a filter paper disc which replaces the lid inside the jar ring. The eggs incubate at the same temperature and humidity used in the controlled temperature room and hatch in the jars.

Larval Diet

The larval diet is a modification of the diet recorded by many workers (1, 3, 6, 10, and footnote 4). Occasional suggested modifications of this diet are passed by personal correspondence between researchers; therefore, it is difficult to give proper credit for specific improvements. I have made only a few slight changes.

About 8 gallons of diet are mixed at one time in a 10-gallon blender (fig. 2) as follows:

1. (a) Stir 720 grams agar into 17,600 milliliters cold distilled water.
(b) Place equal portions of mixture into two large covered enamel pans and autoclave for 4 minutes at 121° C. and 17 pounds per square inch.
(c) Remove, stir, and autoclave for 4 more minutes at the same temperature and pressure.
(d) Remove containers to a cool water bath and stir until the temperature of the dissolved agar reaches 70° C.

2. (a) Place the following in a blender:

1,008 g. casein	900 g. wheat germ
144 g. cellulose (powdered)	288 g. Wesson salt
1,008 g. sucrose	6,400 ml. distilled water

(b) Blend 2 minutes and add 576 ml. microbial inhibitor stock solution containing 117.6 g. sorbic acid and 88.2 g. methyl parahydroxybenzoate and dissolved in 1,000 ml. 95% ethyl alcohol.

3. (a) Blend the blender mixture 1/2 minute and add 120 ml. 10% formaldehyde solution.
(b) Blend 1/2 minute and add 240 ml. potassium hydroxide solution (22.5%).

4. Blend 2 minutes and add the cooled agar.

5. (a) Blend 1 minute and add:

120 g. ascorbic acid	4 g. streptomycin
4 g. kanamycin sulfate	29 g. choline chloride

(b) Add 48 ml. linseed oil plus alpha tocopherol (99:1).
(c) Add 48 ml. vitamin stock suspension. This is prepared by mixing the following:

3.00 g. niacin (nicotinic acid)	2.50 g. folic acid
3.00 g. calcium pantothenate	7.50 g. vitamin B12 (0.1%) triturated with mannitol
1.50 g. riboflavin	
0.75 g. thiamine hydrochloride	
0.75 g. pyridoxine hydrochloride	15.00 g. choline chloride

Add this mixture to 500 ml. 24-hour-old biotin stock solution (prepared by mixing 0.1 g. biotin and 833 ml. distilled water).

6. Stir ingredients into mixture carefully and blend for at least 4 minutes or until homogeneous.

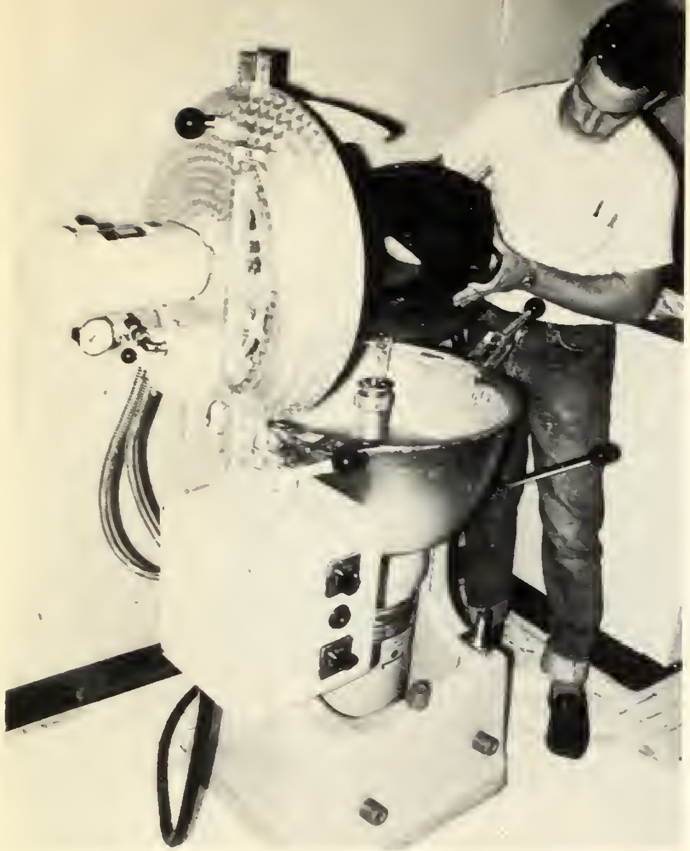

Figure 2.--Pouring cooled, dissolved agar into diet mixture.

Dispensing Diet and Larvae

Burton and Cox (4) described an automated packaging machine for rearing fall armyworms. When it is equipped with a larva dispenser built to the specifications of Burton and Harrell (5), this machine (fig. 3) dispenses 1-ounce plastic cups, fills each with a metered amount of diet, dispenses the larvae onto the diet, and caps each container in one continuous process.

The machine is filled with cups and caps, and the diet is transferred from the blender to the hopper of the machine. A small amount of cornmeal grits is then poured into a pint jar of newly hatched larvae and tumbled until the larvae are mixed with the grits. The napkins on which the eggs were oviposited are removed, and more grits are added and mixed thoroughly until the mixture contains about four to six larvae per 0.4 g., the amount normally dispensed into each cup of diet. The grits-larvae mixture is poured into the hopper of the larva dispenser, and both the diet and the larva dispensers are adjusted to dispense 10 g. of diet and about 0.4 g. of the larvae-grits mixture per cup. The machine can be operated at any speed from 2,000 to 4,500 cups per hour; therefore, when the operator becomes more adept, the speed may be increased toward the maximum.

Figure 3.--Automated packaging machine equipped with a larva dispenser.

As the cups are pushed onto the receiving tray of the machine, they are picked up, five at a time, and placed into preformed papier-mache trays that hold 25 cups. The diet is allowed to solidify before the cups are positioned on their sides so that waste materials do not cover the feeding surface of the diet (fig. 4). The trays are then bound together by a rubber band in groups of six with a piece of cardboard or an empty tray covering the top tray of cups. The larvae are then ready for incubation. They are kept undisturbed at a temperature of 26.5° C. and under constant low-intensity lighting until the desired stadium is reached. Pupation occurs in a cell constructed within the diet and waste materials (fig. 5). An average of 1.50 to 1.75 pupae are collected per cup. Adults emerge from about 87 percent of the pupae.

REARING COSTS

The costs incurred in rearing 63,000 fall armyworms to the adult stage at one time are summarized in table 1. This number of fall armyworms is cited only to indicate the approximate quantity of materials. Large-volume procurement results in reduced prices.

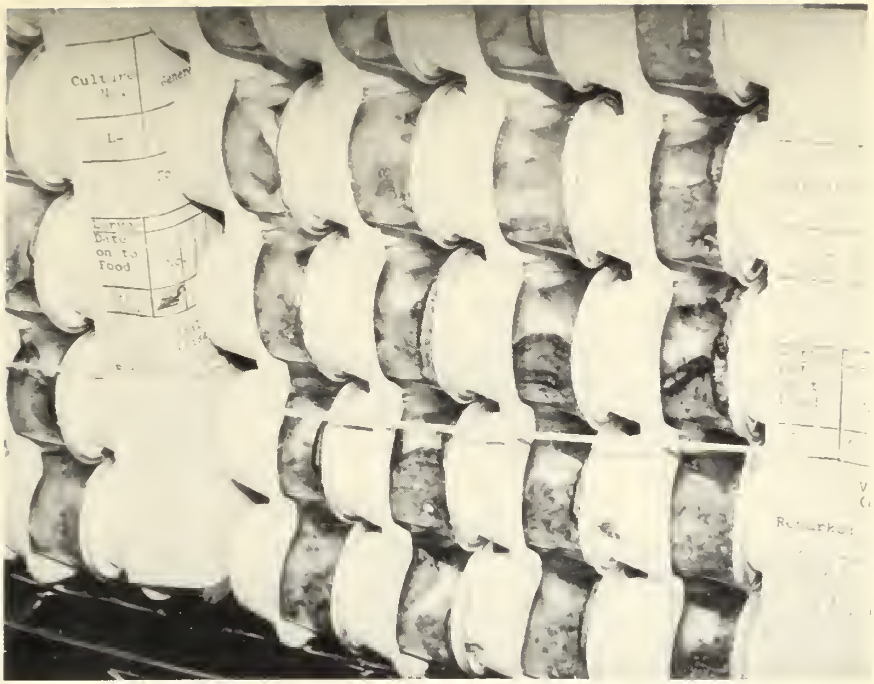

Figure 4.--Cups positioned on their sides.

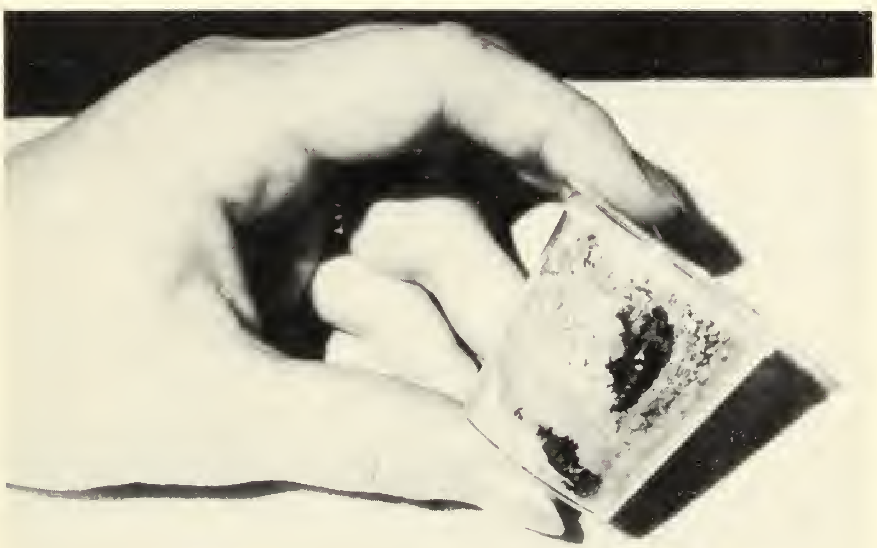

Figure 5.--Pupation in cell constructed within diet and waste materials.

Table 1.--Cost of rearing 63,000 fall armyworms to the adult stage

Item	Cost per 1,000 insects (Dollars)	Total cost (Percent)
Larval stage:1/		
Larval diet	3.50	21
Labor	2.60	16
Cups and caps	3.10	18
Total	9.20	55
Pupal stage:		
Collection of pupae (labor)	4.70	28
Maintenance of laboratory culture (moths)2/	.70	4
Total	5.40	32
Adult stage:		
Loss in emergence	1.90	13
Total	1.90	13
Grand total	16.50	100

1/ Costs at this stage represent 4/7 of actual cost per 1,000 cups since average return to pupal stage is 1.75 per cup.

2/ This cost does not include the cost of rearing adults for breeding stock.

The fact that the fall armyworm is only semicannibalistic contributes more to the efficiency of the system than any other factor. Since an average 1.75 pupae may be reared per cup, the cost of materials and labor for each insect is reduced to almost half that for a totally cannibalistic species. Also, since several larvae are dispensed into each cup, the probability of having cups without larvae is slight, which eliminates the expense of handling uninfested cups.

The cost of materials has been reduced by using lower grade materials where possible, seeking lower priced sources of supply, and buying in quantity when shelf life and storage space permit.

Labor, normally an expensive item in rearing lepidopterous insects, is reduced substantially with the packaging machine, which eliminates many handling techniques previously necessary. However, labor costs for pupae collection continue to be high. An answer to this problem would be a mechanized collection process that could reduce this cost by as much as 25 percent of the total cost per insect.

SUMMARY

A meridic diet has been used with some newly developed techniques and equipment at the Southern Grain Insects Research Laboratory to mass rear the fall armyworm [Spodoptera frugiperda (J. E. Smith)].

The emergence and oviposition cages are 1 cubic foot in size. Paper napkins are used for oviposition sites. Eggs deposited on the napkins are allowed to hatch in jars. Cornmeal grits are then mixed with the larvae. The larval diet (mixed in 8-gallon batches) and the larvae-grits mixture are both dispensed into 1-ounce plastic cups and capped in one continuous process by a modified food-packaging machine.

An average of 1.75 pupae are collected per cup, with adults emerging from 87 percent of the pupae. With these techniques and this equipment, the cost of rearing 1,000 fall armyworms to the adult stage is $16.50.

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